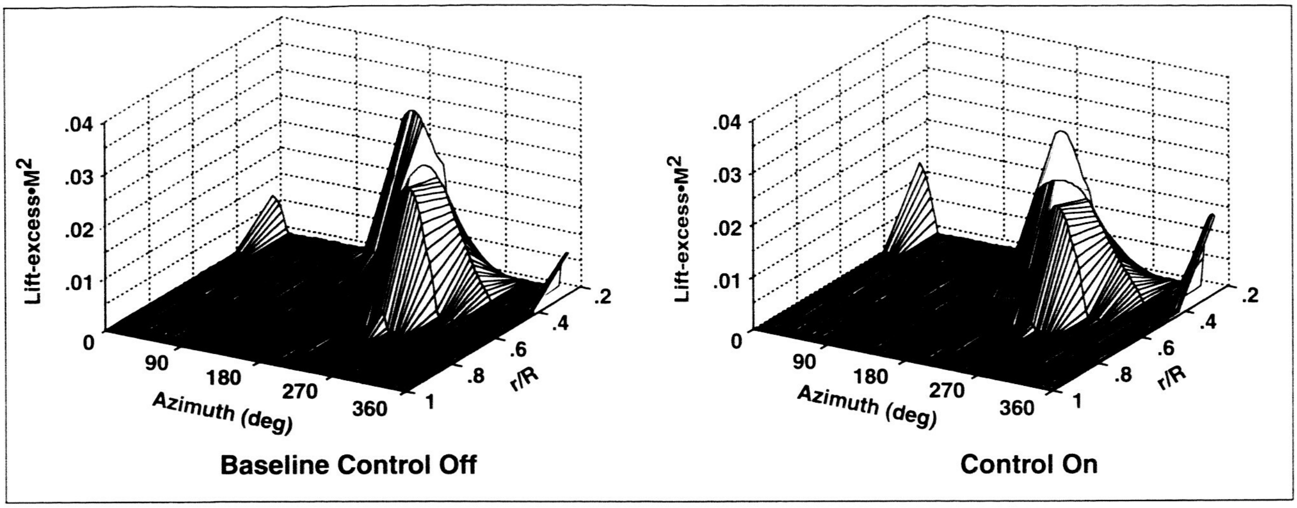

Fig. 1. Effect of higher harmonic input on rotor stall: baseline (left), with 2-per-rev input (right), 102 knots, blade loading C_T/σ 0.13.

Large-Rotor Research Program

Thomas R. Norman, Patrick M. Shinoda, Stephen A. Jacklin

As part of its Rotorcraft Program, NASA is committed to providing the experimental data necessary to (1) validate newly developed predictive capabilities and (2) provide physical insight into those areas where accurate predictive capability does not yet exist. To make the acquisition of these data possible for large-scale rotor systems, NASA and the U.S. Army have developed a new wind tunnel test stand, the Large Rotor Test Apparatus (LRTA). The LRTA (see figure 1) is designed for testing moderate-to-large helicopter blades and tilt rotors up to 50,000 pounds of thrust and 6,000 horsepower and provides unique capabilities that will support both industry and government rotorcraft test programs.

During the past year, two major milestones were reached in the development of the LRTA. The first was the successful calibration of the LRTA rotor balance, following fabrication and assembly of the LRTA rotor balance calibration facility (figure 2). This calibration effort demonstrated the capability of the LRTA balance design to measure rotor hub loads to better than 0.5% full-scale. This level of load measurement accuracy is critical to the successful wind tunnel testing of large rotor systems.

The second milestone reached in FY99 was the design, fabrication, and integration of a state-of-the-art digital rotor-control console for use with the LRTA. This new console provides the digital commands and feedback controls necessary to safely "fly" a rotor system in the wind tunnel. In addition, it provides the capability to control the LRTA dynamic

Fig. 1. Large Rotor Test Apparatus.

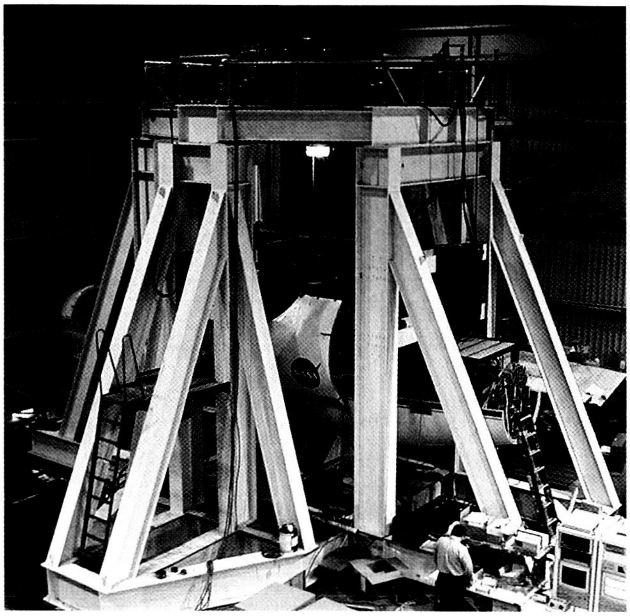

Fig. 2. LRTA rotor balance calibration facility.

actuators, allowing for dynamic high-frequency blade pitch control up to 30 hertz.

With these major milestones met, the LRTA is now ready to become the workhorse facility for NASA's large-rotor experimental programs.

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A Study of Dynamic Stall Using Two-Dimensional Oscillating Wing Experimental Data

Myung Rhee

Dynamic stall produces a significant limitation on the operation and performance of rotorcraft at high-speed. To understand this complex and unsteady aerodynamic phenomenon, a number of studies have been performed to obtain and analyze test data from nonrotating oscillating wings in wind tunnels. Many of these experiments have failed to generate sufficient information to capture the complicated aerodynamic flow characteristics occurring during the dynamic stall process. However, data from one test are now available that afford an opportunity for detailed analysis.

The Army Aeroflightdynamics Directorate performed the test at Ames Research Center in a 7- by 10-foot wind tunnel. The objective of the experiment was to produce high quality data of two-dimensional (2-D) and three-dimensional (3-D) dynamic stall on a semi-span and full-span wing undergoing pitching motions designed to simulate typical rotor blade motions. The airfoil section, a NACA 0015, was tested at a Mach number of 0.3. Various tests were performed for a combination of parameters such as pitch oscillation amplitudes and reduced frequencies. Results from this experiment included the integrated measurements from pressure transducer arrays in the form of lift, drag, and pitching moment coefficients at various wing span locations. Instantaneous pressure distributions have now been made available as a part of the present work; examples are shown in figures 1 and 2.

The initial work here has focused on the 2-D data of the Army experiment to study the vortex development during the dynamic stall process under different test conditions. Detailed analysis has been completed to better understand the flow characteristics of the NACA 0015 airfoil undergoing dynamic motion during dynamic stall. Additionally, the flow behavior data of the NACA 0015 airfoil in this experiment has been compared with NACA 0012 airfoil data previously obtained under similar operating conditions in the same 7- by 10-foot wind tunnel.